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(58) Field of search
G1N

(54) Improvements in tachogenerators

(57) A tachogenerator for a rotary machine such as an electric motor has a stator carrying at least one transmit coil 28 generating a radio-frequency flux field coupling through an air space 32 with at least one receive coil 34. With a plurality of angularly spaced receive coils, each is preferably coupled to a respective transmit coil (rather than using a single transmit coil), radially or axially spaced therefrom; or each transmit coil may be associated with a respective pair of receive coils, one radially spaced and one axially spaced. When the motor is operational, the flux field is cut by a shade ring 38 which rotates with the rotor and has one or more cut-outs, whereby the receive coil cyclically generates digital signals representing the interruptions of the flux field from which may be deduced the speed and/or position of the rotor. These output signals can be used to produce signals controlling energisation of the stator coils or signals which enable speed control. The coils are located within the motor casing, and the radio frequency is at least 50 times as high as the maximum frequency of the flux fields generated by the motor windings, to avoid interference with the sensor by the latter flux fields.

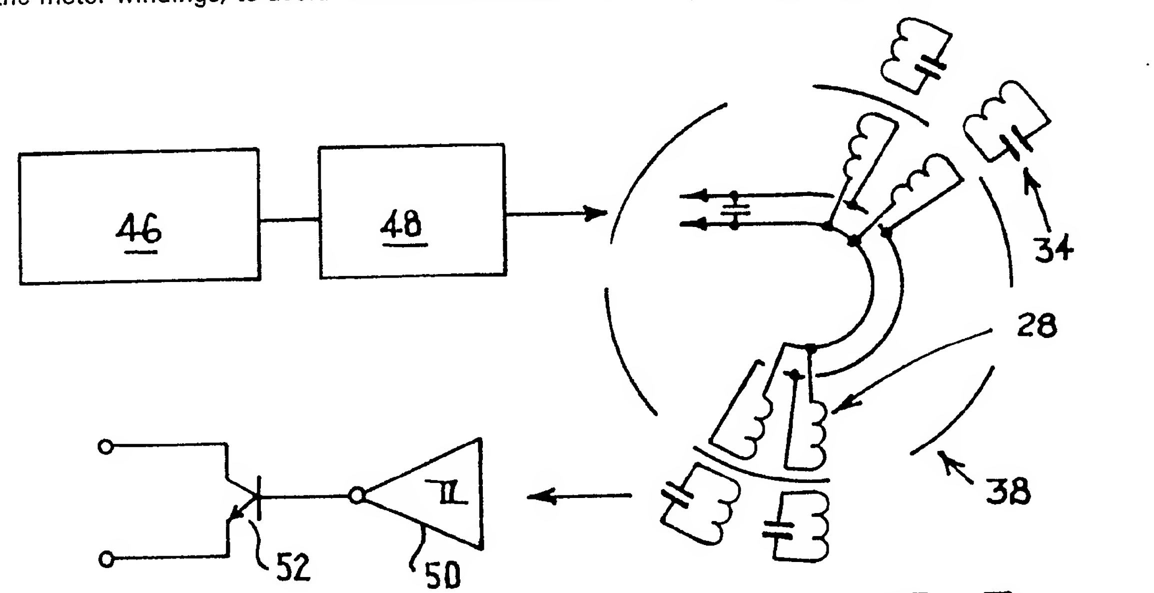

Fig.3

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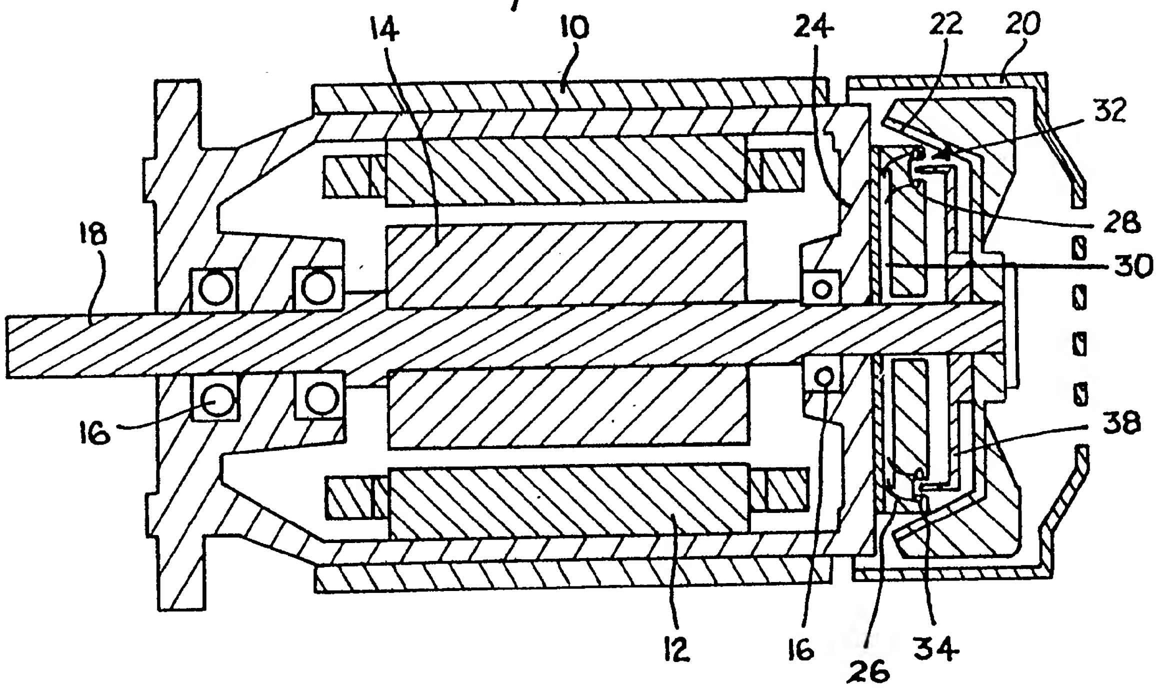


Fig.1

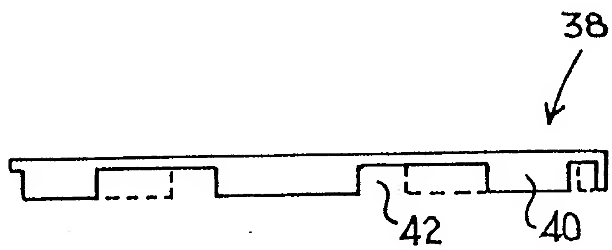


Fig.2

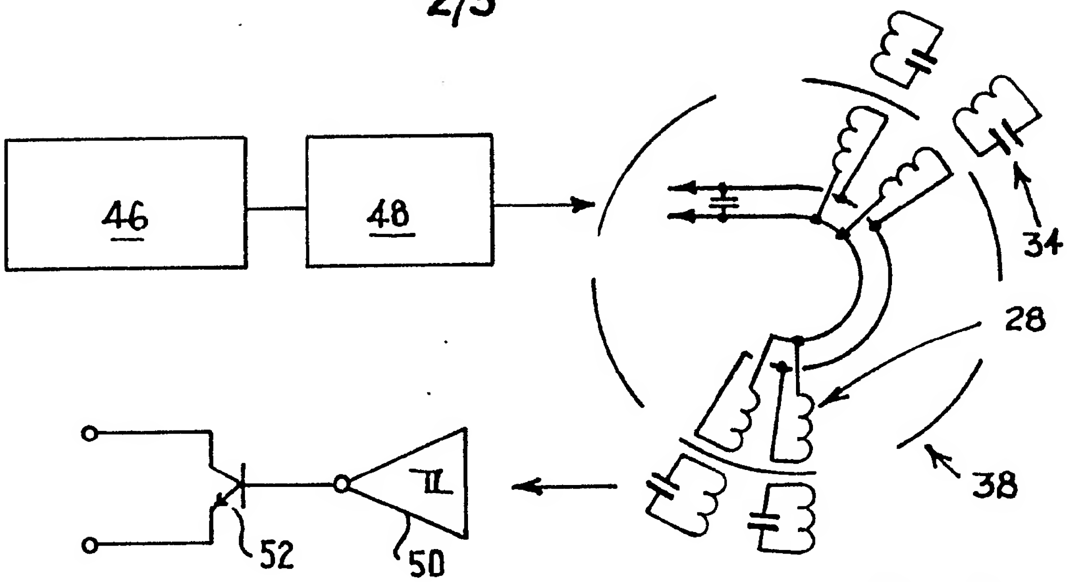


Fig. 3

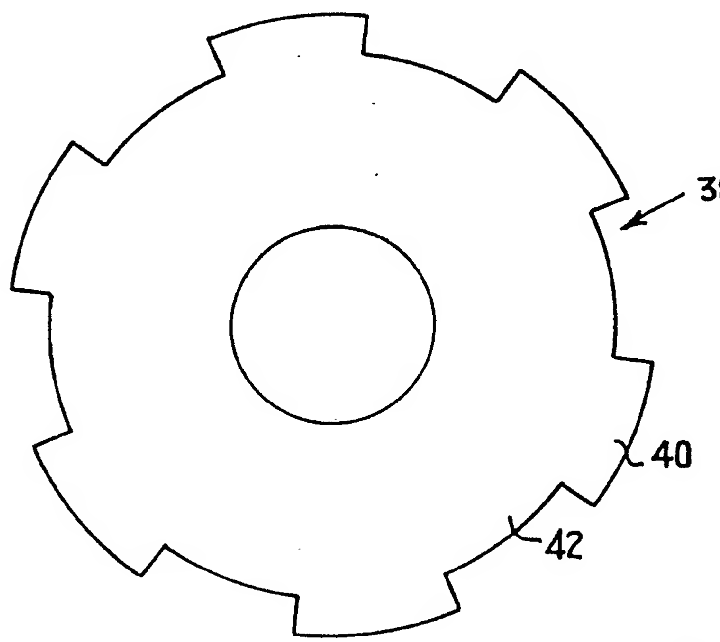
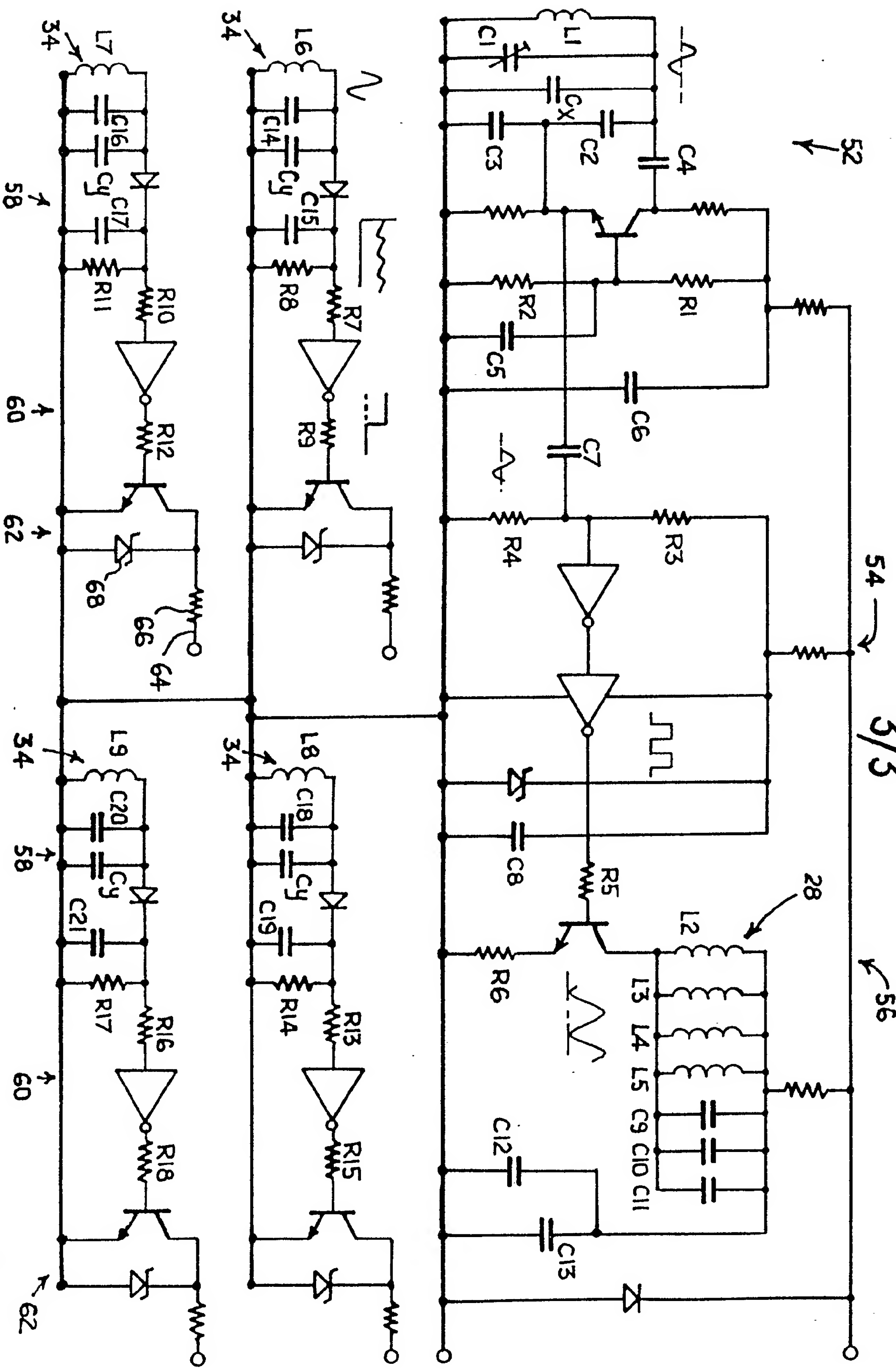


Fig. 5



52
54
56
28
34
58
60
62
64
66
68
L1
C1
Cx
C2
C3
C4
R1
R2
C5
C6
C7
R3
R4
C8
R5
R6
L2
L3 L4 L5 C9 C10 C11
C12
C13
L6
C14
Cy
C15
R7
R8
R9
L7
C16
C17
R10
R11
R12
L8
C18
C19
R13
R14
R15
L9
C20
C21
R16
R17
R18

Fig. 4

SPECIFICATION

Improvements in tachogenerators

Field of the invention

This invention relates to a tachogenerator, i.e. a device for generating an electric signal having a parameter related to the speed and/or position of a rotating member such as a rotor in a rotary machine, typically an electric motor.

Background to the invention

In the prior art it is well known to provide a sensor for detecting the speed and/or position of the rotor of an electric motor in order to generate a speed or position related signal which may be used to control energisation of the motor windings. Various types of such sensor are known.

One such known type of sensor is a D.C. generator; this is expensive if an accurate output is to be achieved, and has a limited working life if brushes and commutator are employed. The latter disadvantage also applies to a rotary switch sensor.

Magslips are also commonly used to generate speed and/or position relates signals to synchronise electrical machines; these also are expensive and their slip rings require relatively frequency maintenance .

Proximity inductance sensors, operating by measurement of changing inductance in the presence of a moving metallic object, can be difficult to stabilise, and with this type of sensor it is difficult to obtain an output of an amplitude independent of rotor speed which is also a failing with the D.C. generator and the conventional A.C. generator sensor.

Although the last mentioned disadvantage can be overcome by an optical sensor, wherein a light beam is cut by a rotating blade, this type of sensor is of limited applicability to machines with higher operating temperatures, and is unreliable in certain environments, especially when a clean atmosphere cannot be maintained.

Tachogenerators are also known wherein a member driven by the rotor is employed to cut a flux field generated by an inductor. These are generally disadvantageous, however, in that interference from the motor flux fields can occur unless the sensor is adequately spaced from the machine or shielded therefrom.

The invention

According to the invention, there is provided a tachogenerator as defined which comprises a sensor having a receive coil positioned within the flux field of a transmit coil, means for energising the transmit coil at a radio frequency, and means carried by the rotating member cyclically to interfere with the coupling between the transmit and receive coils during rotation of the said member, wherein the coils are accommodated within the motor casing and the receive coil is tuned to detect signals within a band substantially in excess of the frequencies associated with the flux fields of the motor windings.

A shade ring is preferred as the said interfering means, preferably of aluminium alloy, but it is practicable to employ a shade ring of any suitable metallic non-ferrous material which will materially interfere with the flux field.

The transmit and receiving coils may be carried by or associated with a stationary member e.g. the stator of an electrical motor.

This tachogenerator has the following advantages:

1 no moving parts subject to wear;
2 reliability in a dirty environment;
3 reduced temperature sensitivity;
4 substantial immunity to influence by the flux field of the motor windings;
5 amplitude of output independent of rotor speed;
6 possibility of detecting rotor pole position by use of a shade ring having multiple interruptors;
7 providing a digital output to indicate speed and/or which can be electronically processed to control energisation of motor windings;
8 possibility of using multiple receive coils to enable position sensing.

Thus, with regard to advantage 3, the receive coil(s) may be tuned to detect signals within a broad bandwidth, so that frequency drift at the transmit coil due to changing operating temperatures is of no significance. This broad bandwidth within which the receive coil(s) are operative remains appreciably above the frequencies associated with the flux fields of the motor windings, thus maintaining advantage 4. It thereby also follows that, for example in an electric motor, the sensor can be fitted within the motor casing, with conductors feeding the output to the more sensitive processing electronics outside the casing.

With regard to advantage 6, a single transmit coil and a single receive coil with a shade ring having one cut-out will produce a single change in the r.f. signal which typically will lead to a single output pulse per revolution of the rotor. However, if the rotor of an electric motor has n

poles, a shade ring having n or n × m appropriately positioned cut-outs will detect the positions of all the rotor poles as the rotor rotates. Moreover, it follows that, by use of two or more angularly spaced receive coils, preferably each coupling to a respective transmit coil rather than using a single transmit coil, the sequence of outputs can be processed to determine the position of the rotor, as well as its speed.

The output of the sensor, processed by the electronics outside the machine casing, can not only generate control signals controlling energisation of the motor windings, but can for example be converted to a signal for speed control purposes.

In a practical arrangement, the transmit and receive coils are radially spaced with respect to the axis of the machine, but they may alternatively be axially separated. These alternatives provide the possibility of using two receive coils per transmit coil, one spaced in the radial direction and one spaced in the axial direction.

Outside processing electronics will be connected to a local detector circuit responsive to the output of the receive coil(s). As the conductor lead from this detector circuit may be relatively long, it may pick up transients which could affect the final output used for control or measurement purposes. This effect may be prevented by provision of a protective circuit, which has a resistor (100 R) and zener diode connected on the output side of the detector, in order to protect a detector output transistor.

In a preferred arrangement, the radio frequency at which the sensor operates is at least 50 times as high as the maximum frequency of the flux fields of the motor windings during prescribed operation of the machine.

For example, the operating frequency of the sensor may be in excess of 500 KHz. In the case of a reluctance motor, possible modes of operation include d.c. energisation of the motor windings with a current varying between two levels (neither being zero). This mode of operation typically causes generation of motor winding up to about one half the motor speed, say in the range 800 to 1000 Hz. An alternative mode of operation switches each motor winding coil on/off during each revolution. Depending on the number of motor winding coils, the windings may then generate flux fields of a somewhat higher frequency, possibly in the range 1 to 10 KHz. The radio frequency band of the sensor is still at least 50 times higher, and no interference will occur, even with the sensor located within the motor casing.

Description of the drawings

The invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 illustrates a motor and tachogenerator embodying the invention, in axial cross-section;

Figure 2 shows a shade ring;

Figure 3 shows the complete sensor arrangement diagrammatically;

Figure 4 is a circuit diagram of the associated electronics, with marked waveforms (w/f); and

Figure 5 illustrates a shade ring for use in a modified embodiment.

Description of embodiment

Fig. 1 diagrammatically illustrates a reluctance motor having a casing 10, multipole stator 12, multipole rotor 14, rotor bearings 16 and output shaft 18. The casing includes an end cover 20 within which a fan 22 is located.

Fixed to the stator 12 via a casing plate 24 carrying one set of bearings 16 is an annular plate 26 of insulating material having a thickened central portion accommodating r.f. transmit coils 28 and a circuit board 30 for causing each said transmit coil to generate a r.f. flux field in the form of a beam extending across arcuate gaps 32 on the other side of which receive coils 34 are accommodated within thickened peripheral portions of the insulating plate.

Carried by the rotor 14 within the casing end cover 20 is an aluminium shade ring 38 (see Fig. 2) having an interrupted peripheral flange, i.e. portions of the flange are cut away, forming a series of arcuate blades which rotate through the annular gaps 32 when the motor is operational, thus interrupting the r.f. flux coupling between the transmit and receive coils. The output side of the receive coils connects to a detector circuit also carried by circuit board 30.

More specifically, a preferred embodiment has two pairs of adjacent transmit coils 28, the transmit coils of each pair being arcuately spaced about 5 degrees apart and the pairs being arcuately spaced about 120 degrees apart, together with two pairs of correspondingly positioned receive coils 34. The shade ring 38 has six arcuate blades 40 alternating with six cut-outs 42, each of 30 degrees arcuate extent. The six cut-outs defining the six blades are provided for a rotor having six poles.

In use, the receive coils 34 output pulses corresponding to the interruptions of the r.f. beams (flux fields) generated by the transmit coils. These outputs are detected and fed to electronic processing circuitry outside the motor casing. This outside electronics generates signals controlling energisation of the stator windings (the stator has eight poles in the preferred

embodiment) and may also generate analogue signals for speed control purposes or the like. A conductor lead connecting between the outside electronics and the circuit board 30 has an input power conductor for the transmitter circuitry and four output conductors, one from the detector associated with each of the four receive coils.

Fig. 3 shows the sensor arrangement diagrammatically. The four transmit coils 28 are commonly fed from a tuned r.f. oscillator 46 via amplifier 48. The output of each receive coil 34 drives a Schmitt trigger 50 leading to a transistorised output circuit 52.

Fig. 4 shows the electronic circuitry on the circuit board 30. The transmitter circuitry is shown at the top. It comprises an r.f. oscillator section 52, such as a Colpitts oscillator, a peak voltage stabilising section 54, and an amplifying section 56 feeding the transmit coils 28, the latter being connected in parallel. The receiver circuitry at the bottom of the figure comprises four similar sections, one for each receive coil 34. Each receiver section comprises a rectifier stage 58, Schmitt trigger stage 60 driven between high and low levels in accordance with the interruptions of the flux field, and output stage 62. The lead 64 to the outside processing circuitry from the output stage 62 may be very long, and is therefore liable to pick-up transients. The resistor 66 and Zener diode 68, on the output side of the detector circuitry, protect the output transistor 70 from such transients.

In the embodiment described, the r.f. flux fields are transmitted radially outwards by the transmit coils 28 to enable flux field coupling with receive coils 34 spaced radially outwardly of the transmit coils. However, the positions of the transmit and receive coils could be reversed.

Moreover, flux field coupling in the axial direction is also possible, although at the expense of an axially thicker insulating plate. A flat shade ring 38A for use in such a modified embodiment is shown in Fig. 5. In the modified embodiment, a screen is desirable to shield the sensor arrangement in the axial direction.

In general, however, in both embodiments, the ability to incorporate the sensor within the motor casing is enabled by sufficiently separating the frequency of operation of the sensor from the frequencies of the flux fields generated by the motor windings that interference with the sensor by the latter flux fields is avoided or minimised.

The above-described reluctance motor may be operated in either one of two ways. In one mode, the motor windings are d.c. energised with a current modulated between two levels. Typically, the motor windings generate flux fields of the order 800 to 1000 Hz. In another mode of operation, each motor coil is switched on/off during each revolution of the rotor. In this instance flux fields are generated by the motor windings at a frequency of the order of 2.4 KHz, rising to about 6.4 KHz with motor operation at 4000 r.p.m.

In both modes of operation, the sensor operates at a radio frequency band centred on 550 KHz, which is at least 86 times as high as the maximum frequency of the motor winding flux fields.

Component Values

L1	130 microHenrys	C1	40pF max
L2	82 "	C2	1500pF
L3	82 "	C3	1000pF
L4	82 "	C4	330pF
L5	82 "	C5	100nF
L6	82 "	C6	10nF
L7	82 "	C7	220pF
L8	82 "	C8	10nF
L9	82 "	C9	1500pF
		C10	1500pF
		C11	1000pF
R1	10K	C12	10nF
R2	2KZ	C13	15mF
R3	100K	C14	1000pF
R4	100K	C15	330pF
R5	10K	C16	1000pF
R6	100R	C17	330pF
R7	47K	C18	1000pF
R8	47K	C19	330pF
R9	100K	C20	1000pF
R10	47K	C21	330pF
R11	47K		
R12	100K		
R13	47K		
R14	47K		
R15	100K		
R16	47K		
R17	47K		
R18	100K		

CLAIMS

1. A tachogenerator as defined herein comprising a sensor having a receive coil positioned within the flux field of a transmit coil, means for energising the transmit coil at a radio frequency, and means carried by the rotating member cyclically to interfere with the coupling between the transmit and receive coils during rotation of the said member, wherein the coils are accommodated within the motor casing and the receive coil is tuned to detect signals within a band substantially in excess of the frequencies associated with the flux fields of the motor windings.

2. A tachogenerator as claimed in claim 1, having a plurality of angularly spaced receive coils.

3. A tachogenerator according to claim 2, having a plurality of angularly spaced transmit coils, one for each receive coil.

4. A tachogenerator according to any of claims 1 to 3, wherein the or each receive coil is spaced in the radial direction from the corresponding transmit coil.

5. A tachogenerator according to any of claims 1 to 3, wherein the or each receive coil is spaced in the axial direction from the corresponding transmit coil.

6. A tachogenerator according to any of claims 1 to 5, wherein the transmit and receive coils are accommodated in an insulating plate fixed relative to the stator within the machine casing, said plate also accommodating a circuit board carrying a r.f. generator for supplying the transmit coil(s) and detector circuitry for the receive coil(s).

7. A tachogenerator according to any of claims 1 to 6, wherein the interfering means carried by the rotating member has a plurality of peripheral blades for cutting the flux field coupling between the transmit and receive coils.

8. A tachogenerator according to any of claims 1 to 7, wherein the interfering means carried by the rotating member is a shade ring of a metallic non-ferrous material.

9. A tachogenerator according to claim 8, having an aluminium shade ring.

10. A tachogenerator according to claim 6 or any claim appendant thereto, having an output transistor in the detector circuitry for each receive coil, and circuit means for protecting said output transistor from transients induced in a long output lead connected to outside processing circuitry.

11. A machine incorporating the tachogenerator of any of claims 1 to 10.

12. A machine according to claim 11, in the form of an electric motor.

13. A machine according to claim 12, wherein the rotor has n poles and the shade ring has $n \times m$ flux cutting blades, where m is an integer.

14. A machine according to claim 13, having four transmit and four receive coils, correspondingly arranged in two pairs with the coils of each pair spaced apart by an angle of about 5 degrees and the pairs angularly spaced by about 120 degrees.

15. A tachogenerator according to any of claims 1 to 14, wherein the receive coil is tuned to detect radio frequencies within a band at least 50 times higher than the maximum frequency of the flux fields of the motor windings during operation of the machine.

16. A tachogenerator according to claim 15, wherein the band of frequency of operation of the sensor is centred on 550 KHz.

17. A tachogenerator substantially as hereinbefore described with reference to the accompanying drawings.

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